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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE BY EPS(EXPANDED POLYSTYRENE) BEADS IN CONCRETE BLOCKS

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A B S T R A C T

Building energy consumption has rapidly expanded and now makes up 37% of all yearly primary energy consumption in India due to the social economy's rapid growth. The need to cut back on building energy use is critical. Light aggregate concrete made of both organic and inorganic elements is known as expanded polystyrene (EPS) concrete. It has a lower density, lighter weight, greater thermal insulation performance, and superior sound insulation performance when compared to regular concrete. Both the weight of the structure and the energy consumption of the building might be greatly reduced. It is the perfect material for wall insulation. The problem of environmental pollution can be efficiently eliminated by using EPS concrete, which consumes a significant number of recoverable EPS particles. As a result, EPS concrete is a type of inexpensive, eco-friendly, green thermal insulation material that reduces waste generation, saves energy, and is also cost-effective. This material may present new opportunities for green building and building energy conservation.

Keywords*: EPS, Compressive Strength, Light Weight Concrete, EPScrete.*

1. INTRODUCTION

EPS beads stands for Expanded Polystyrene beads. EPS is generally used as a single use packaging material and once used, these are discarded and disposed as a waste material in the dump yards. Being Non-Biodegradable, the EPS can take decades if not centuries to completely dispose within the soil layers. The main focus of our project is to eye the possibility of using a single use packaging waste material for the benefit of mankind and use these EPS beads in a way that apart from being a beneficial to the environment, it is made cost friendly and economical for it to be used in the construction field as well. With the greater requirement for construction materials in an industry, for the sustainable development there should be essential to use alternative materials. Concrete is most flexible material for construction of building. The basic of structural application says, the structure self-weight is quite important it showsa maximum portion of the load detail. Substituting partially or completely the coarse part of aggregate with EPS beads produces lightweight concrete blocks they can achieve a reliable compressive strength. Expanded Polystyrene beads (EPS) are a generally utilized as a partial replacement for coarse aggregates and can be effectively mixed with concrete or mortar to make light-weight concrete blocks with an extensive variety of densities beneficially.

This project work mainly focuses on the performance of Styrofoam as light-weight aggregates and its ability to reduce dead load without sacrificing the strength. Styrofoam particles were used to partially replace the coarse aggregate in a concrete block. Compressive strength and unit weight of normal density concrete blocks by using standard M25 Grade (1:1:2) which was used as a benchmark for the comparison with Styrofoam light-weight concrete blocks.

Nomenclature

EPS- Expanded Polystyrene Beads
EPScrete- Expanded Polystyrene Beads Concrete
UPV- Ultrasonic Pulse Velocity
IS- Indian Standard

2. OBJECTIVES

- Laboratory evaluation of the performance of Expanded polystyrene (Styrofoam) beads in concrete of M25 grade as lightweight coarse aggregate to reduce dead load without significant reduction in compressive strength.
- To perform tests on workability of fresh concrete (slump cone, vee-bee, compaction factor tests and also the tests on hardened concrete (compression, split tensile and flexural strength tests) along with the non-destructive tests (rebound hammer test, UPV test, etc.).
- To compare the EPS concrete block mass with the mass of the normal concrete block that is used currently in construction and calculate the reduction in their weights, and also to compare their strengths.
- To determine the strength development of EPS concrete after curing for 7 and 28 days.

3. MATERIALS

The following materials were used during the project work: -

- **Cement-** Cement of OPC53 grade with specific gravity 3.15 was employed in this work.
- **Coarse Aggregate-** Locally sourced coarse aggregates with a specific gravity of 2.65 that passed through a 16mm IS Sieve and were retained on a 12.5mm IS Sieve were used.
- **Fine Aggregate-** Locally produced M-sand measuring 4.75mm or less and having a specific gravity of 2.79 is used in this project.
- **Expanded Polystyrene beads-** In this study, 0.046 specific gravity EPS beads that remain on a 10mm IS Sieve are employed.

Fig 1: EPS Beads

- **Potable Water-** In accordance with IS456:2000, potable fresh water from local sources was used for mixing and curing.

4. METHODOLOGY

For the experimental method, specimens with EPS replacing coarse aggregates by 40, 45, and 50 percent were used. Following the acquisition of thematerials, they were combined and cast to create 24 of each of the following: cubes, cylinders, and beams. A total of 72 specimens were cast and tested in accordance with the various standards listed by their individual IS codes, which will be described further. Tests were conducted in accordance with the mix proportions of M25 grade (from IS 10262:2019), and the results were tabulated.

4.1 Tests on Wet Concrete

Tests on wet concrete were executed as per the specifications mentioned in IS 1199:1959.

- **Slump Cone Test**- This test method outlines the steps to take in order to determine the consistency of concrete where the nominal maximum size of the aggregate does not exceed 38 mm using the slump test, either in the laboratory or as work is being done in the field.
- **Vee-Bee Consistometer Test**- The vibrator table is 380 mm long, 260 mm broad, and is raised approximately 305 mm above the ground on rubber shock absorbers. A vibrometer that uses either 65 or 220 volts of three-phase, 50-cycle alternating current is positioned beneath the table and is supported by a base that rests on three rubber feet. The metal pot (A) is filled with a sheet metal cone that is open at both ends, and the metal pot is secured to the vibrator table using two wingnuts. The Vee-Bee consistency is measured in seconds.

4.2 Destructive Tests

Destructive Tests on hardened concrete specimens after being cured for 7 and 28 days. The tests were done as per the specifications of IS 516:1958.

- **Compressive Strength Test**- Two steel bearing plates with hardened faces will be included in the testing equipment. One of the platens, preferably the one that would typically be on the upper surface of the specimen. The maximum force applied to the samples will then be noted, along with the concrete's appearance and any odd features that appear. Testing was done on cubes of size 150mm x 150mm x 150mm.

- **Split Tensile Test**- One test carried out on hardened concrete cylinder is the splitting tensile strength test. One of the fundamental properties of concrete is its tensile strength. Concrete is a strong and long-lasting building material. Hence Concrete that has already solidified must be tested. Apply load gradually at a 0.7 to 1.4 MPa/min (1.2 to 2.4 MPa/min according on IS 5816:1999) rate. Keep track of the specimen's breaking load.Testing was done on cylinders of diameter 150mm and height 300mm.

- **Flexure Strength Test**- To ascertain a material's flexibility or bending capabilities, flexural testing is utilized. It entails positioning a sample between two points or supports and applying a load with a third point or two points, known as 3-Point Bend testing. Testing was done on beams ofsize 500mm x 100mm x 100mm.

4.3 Non-Destructive Tests

Non-Destructive Tests were also done on cubes as per specifications mentioned in (IS 13311:1992)

- **Ultrasonic Pulse Velocity Test**- An electro-acoustical transducer produces the ultrasonic pulse. The pulse undergoes several reflections at the borders of the various material phases in the concrete when it is driven into it by a transducer. Transverse, longitudinal, and surface (Rayleigh) waves make up a complicated system of stress waves that are generated. The commencement of the longitudinal waves, which are the fastest to arrive, is detected by the receiving transducer. The pulse velocity to be calculated using the formula mentioned in the IS code book mentioned above.

- **Rebound Hammer Test**- Using the apparatus test should be done such that A dry, clean, and smooth surface should be used for testing. If there is scale that is just loosely adherent, it should be removed using a grinding stone or wheel. Rough surfaces brought on by insufficient compaction, grout loss, spalled or tooled surfaces should be avoided since they do not produce accurate results. At least 20 mm should separate the point of impact from any edge or shape discontinuity. The final strength is calculated as per the graph given in the IS code book mentioned above.

5. RESULTS

5.1 Slump Cone Test

The workability of both fresh normal concrete and EPS concrete was determined. Fresh concrete was found to be highly workable in all cases. The slump was 110 mm for normal concrete and 104-112 mm for EPS concrete based on replacement percentages.

Table 1: Results of Slump Cone Test

Sl. No.	Specimen	Slump Value (in mm)
1	Normal Concrete	110
2	40% replaced EPS concrete	104
3	45% replaced EPS concrete	109
4	50% replaced EPS concrete	112

5.2 Vee-Bee Consistometer Test

The Vee-Bee time for both types of fresh concrete (normal and EPS) was between 2.7 and 2.3-2.5 seconds, respectively. This determines the fresh concrete's semi-fluid nature.

Table 2: Results of Vee Bee Consistometer Test

Sl. No.	Specimen	Vee-Bee time (in seconds)
1	Normal Concrete	2.7
2	40% replaced EPS concrete	2.3
3	45% replaced EPS concrete	2.5
4	50% replaced EPS concrete	2.5

5.3 Compressive Strength Test

After 7 days of strength development, the normal cube's average compressive strength was 23.94 MPa.

The average compressive strength of EPS cubes, on the other hand, was found to be 16.18, 14.79, and 12.94 MPa for 40, 45, and 50% replacement of coarse aggregates with EPS beads, respectively.

After 28 days of strength development, the normal cube's average compressive strength was 37.68 MPa.

The average compressive strength of EPS cubes, on the other hand, was found to be 23.45, 21.44, and 18.76 MPa for 40, 45, and 50% replacement of coarse aggregates with EPS beads, respectively.

Fig 2: Compressive Strength Test of Normal Concrete Cube

Table 3: Results of Compressive Strength Test

Sl. No.	Specimens	Compressive Strength after 7 days (in MPa)	Compressive Strength after 28 days (in MPa)
1	Normal Cube	23.94	37.68
2	40% replaced EPS cube	16.18	23.45
3	45% replaced EPS cube	14.79	21.44
4	50% replaced EPS cube	12.94	18.76

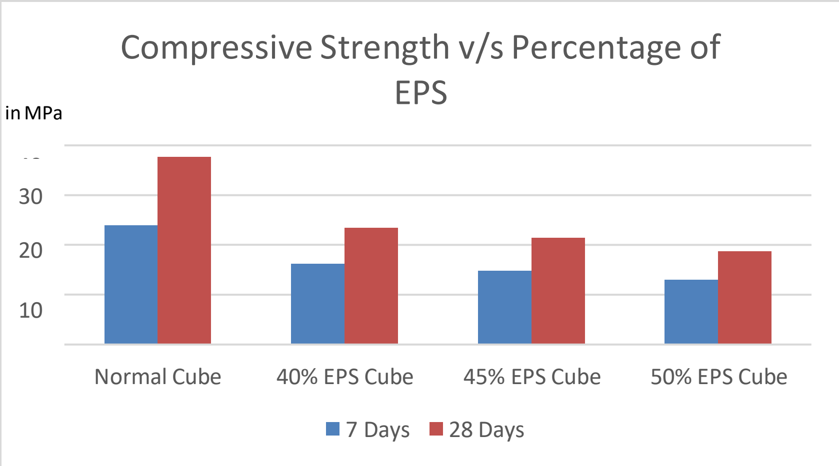

Fig 3: Graphical Representation of Compressive Strength v/s Percentage of EPS

5.4 Split Tensile Test

After 7 days of strength development, the average split tensile strength of the normal cylinder was 2.21 MPa.

Similarly, the average split tensile strength for the EPS cylinders were found to be 1.53, 1.33, and 1.27 MPa for 40, 45, and 50% replacement of coarse aggregates with EPS beads respectively.

After 28 days of strength development, the average split tensile strength of the normal cylinder was 3.32 MPa.

Also, the average split tensile strength for the EPS cylinders were found to be 2.35, 2.11, and 1.87 MPa for 40, 45, and 50% replacement of coarse aggregates with EPS beads respectively.

Fig 4: Cross section of a 40% replaced EPS concrete cylinder following a 28-day split tensile test.

Table 4: Results of Split Tensile Test

Sl. No.	Specimens	Split Tensile Strength after 7 days (in MPa)	Split Tensile Strength after 28 days (in MPa)
1	Normal Cylinder	2.21	3.32
2	40% replaced EPS cylinder	1.53	2.35
3	45% replaced EPS cylinder	1.33	2.11
4	50% replaced EPS cylinder	1.27	1.87

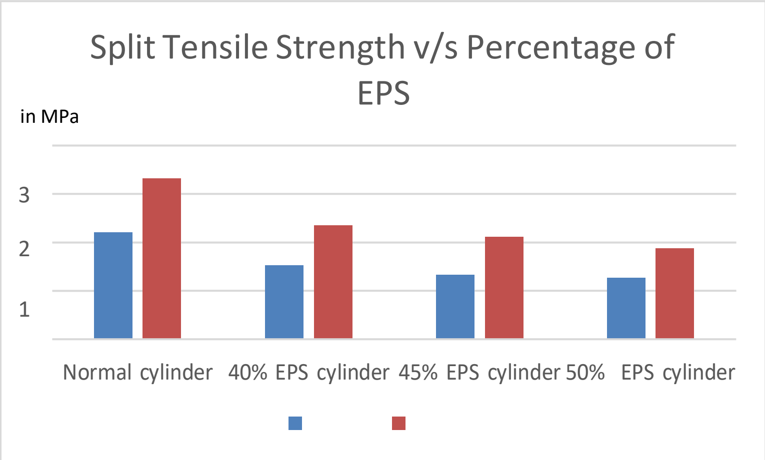

Fig 5: Split Tensile Strength v/s Percentage of EPS

5.5 Flexural Strength Test

After 7 days of strength development, the average flexural strength of the normal beam was 4.69 MPa.

Similarly, the average flexural strength for the EPS beams were found to be 2.41, 1.89, and 1.67 MPa for 40, 45, and 50% replacement of coarse aggregates with EPS beads respectively.

After 28 days of strength development, the average flexural strength of the normal beam was 7.0 MPa.

Similarly, the average flexural strength for the EPS beams were found to be 3.5, 2.75, and 2.5 MPa for 40, 45, and 50% replacement of coarse aggregates with EPS beads respectively.

Table 5: Results of Flexural Strength Test

Sl. No.	Specimen	Flexural Strength Test after 7 days (in MPa)	Flexural Strength Test after 28 days (in MPa)
1	Normal Beam	4.69	7.0
2	40% replaced EPS beam	2.41	3.5
3	45% replaced EPS beam	1.89	2.75
4	50% replaced EPS beam	1.67	2.5

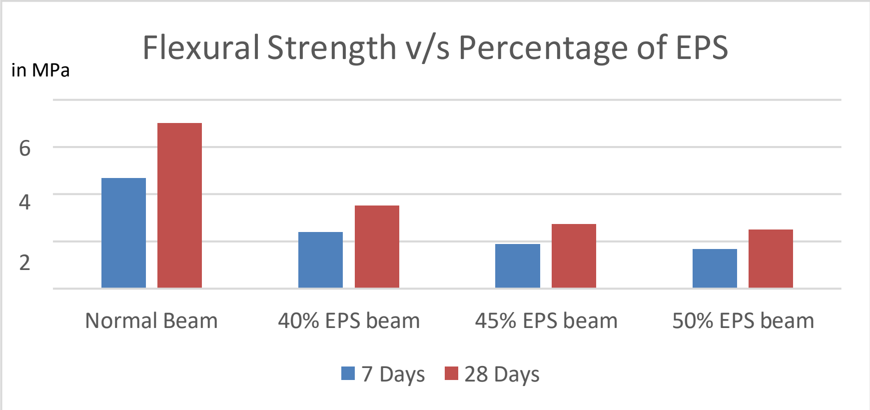

Fig 6: Flexural Strength v/s Percentage of EPS

5.6 Ultrasonic Pulse Velocity Test

After 28 days of strength development, the pulse velocity in the normal concrete cube was calculated to be 4.7 km per second which determines excellent quality of concrete.

Moreover, the pulse velocities of EPS cubes were 4.3,4.1,4.0 km per second for 40, 45, and 50% replacement of coarse aggregates with EPS beads respectively. These results indicate good quality of concrete.

Fig 7: Ultrasonic Pulse Velocity Test of 40% replaced EPS concrete cube after 28 days of curing.

Table 6: Results of Ultrasonic Pulse Velocity Test

Sl. No.	Specimen	Pulse Velocity (km/sec)
1	Normal cube	4.7
2	40% replaced EPS cube	4.3
3	45% replaced EPS cube	4.1
4	50% replaced EPS cube	4.0

5.7 Rebound Hammer Test

Angle of Attack: 0° (Horizontal)

The average rebound number for the normal cube was 27. Hence, the corresponding compressive strength was obtained as 19 MPa.

Also, for 40, 45, and 50% EPS-replaced cube, the average rebound number was around 20, and hence the compressive strength can be said to be to be 10 MPa.

Table 7: Results of Rebound Hammer Test

Sl. No.	Specimen	Compressive Strength (in MPa)
1	Normal cube	19 MPa
2	40% replaced EPS cube	10 MPa
3	45% replaced EPS cube	10 MPa
4	50% replaced EPS cube	10 MPa

5.8 Weigh Reduction

The weight of the specimen decreases as the replacement percentage of the EPS beads in the concrete increases. When compared to their normal counterparts, the EPS specimens had significantly reduced their dead weight. During the experimental study, participant specimens lost up to 41% of their body weight.

Table 8: Weight Reduction in cubes after 28 days of strength development

Sl. No.	Specimen	Weight after 28 days (in kg)	Weight Reduction (in kg)
1	Normal Cube	8.174	-
2	40% replaced EPS cube	5.936	2.238 (27%)
3	45% replaced EPS cube	5.127	3.047 (37%)
4	50% replaced EPS cube	4.782	3.392 (41%)

Table 9: Weight Reduction in cylinder after 28 days of strength development

Sl. No.	Specimen	Weight after 28 days (in kg)	Weight Reduction (in kg)
1	Normal Cylinder	12.795	-
2	40% replaced EPS cylinder	9.212	3.583 (28%)
3	45% replaced EPS cylinder	8.443	4.350 (34%)
4	50% replaced EPS cylinder	7.677	5.118 (40%)

Table 10: Weight Reduction in beams after 28 days of strength development

Sl. No.	Specimen	Weight after 28 days (in kg)	Weight Reduction (in kg)
1	Normal Beam	12.234	-
2	40% replaced EPS beam	9.840	2.394 (19%)
3	45% replaced EPS beam	9.293	2.941 (24%)
4	50% replaced EPS beam	8.372	3.863 (32%)

6. CONCLUSION

The results and discussion have been done to conclude the project to achieve a main objective of our project work. We have found that the strength and reduction after conducting the various tests by increasing the percentage of EPS beads such as 40%, 45%, 50% in concrete, the strength has been decreased, but the weight reduction has been achieved to make the light weight concrete blocks.

We have concentrated on its potential to minimize dead load without compromising compressive strength. Based on the observations and testing performed on the Styrofoam Light-weight Concrete blocks, EPS is used in an experiment in concrete where it is developed to implement the mixing procedure and to calibrate and evaluate the strength of the blocks. Styrofoam concrete blocks does not improve the compressive strength, but will reduces its self-weight which can be used for non-load bearing walls such as partition walls, facades etc.

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